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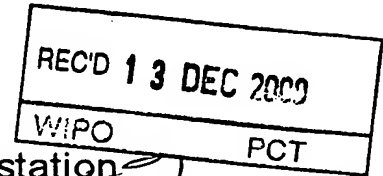
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Patentanmeldung Nr.   Patent application No.   Demande de brevet n°

99118990.3

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For the President of the European Patent Office

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Blatt 2 der Bescheinigung
Sheet 2 of the certificate
Page 2 de l'attestation

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Demande n°:

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Method for processing video pictures for display device

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The original title of the application reads as follows:
Method for processing video pictures for display on a display device.

EPA/EPO/OEB Form 1012 - 11.00

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Method for processing video pictures for display on a display device

The invention relates to a method for processing video pic-
5   tures for display on a display device.
More specifically the invention is closely related to a kind
~~of video processing for improving the picture quality of~~
pictures which are displayed on matrix displays like plasma
display panels (PDP) or other display devices where the
10 pixel values control the generation of a corresponding num-
ber of small lighting pulses on the display.

The Plasma technology now makes it possible to achieve flat
color panel of large size (out of the CRT limitations) and
15 with very limited depth without any viewing angle con-
straints.
Referring to the last generation of european TV, a lot of
work has been made to improve its picture quality. Conse-
quently, a new technology like the Plasma one has to provide
20 a picture quality as good or better than standard TV tech-
nology. On one hand, the Plasma technology gives the possi-
bility of "unlimited" screen size, of attractive thickness
... but on the other hand, it generates new kinds of arte-
facts which could degrade the picture quality.
25 Most of these artefacts are different as for TV picture and
that makes them more visible since people are used to seeing
old TV artefacts unconsciously.
The artefact, we will study here, is called "dynamic false
contour effect" since it corresponds to disturbances of gray
30 levels and colors in the form of an apparition of colored
edges in the picture when an observation point on the PDP
screen moves. The degradation is most visible when the image
has a smooth gradation like skin...
The next figure shows the simulation of such a false contour
35 effect on a natural scene with skin areas :

In addition, the same problem occurs on static images when
observers are moving their heads and that leads to the con-
5   clusion that such a failure depends on the human visual per-
ception and happens on the retina...
A lot of algorithms today are based on motion estimator in
order to be able to anticipate the motion of the eye to re-
duce or suppress this false contour effect. However, these
10   different algorithms provide solution for false contour
without any information concerning the motion estimator
used.
In the past, the motion estimator evolution was mainly fo-
cused on flicker-reduction for european TV (e.g. from 50Hz
15   to 100Hz) or proscan conversion and for compression in the
scope of MPEG-encoder and so one. Nevertheless, the problems
which have to be solved for such applications are different
from the PDP dynamic false contour issue. For that reason,
we propose in this document a way to improve the quality of
20   the false contour reduction using standard motion detectors
with a post-processing of the estimated motion-vectors ac-
cording to the human visual system.

A Plasma Display Panel (PDP) utilizes a matrix array of dis-
charge cells which could only be "ON" or "OFF". Also unlike
a CRT or LCD in which gray levels are expressed by analog
control of the light emission, a PDP controls the gray level
5   by modulating the number of light pulses per frame. This
time-modulation will be integrated by the eye over a period
corresponding to the eye time response.

When an observation point (eye focus area) on the PDP screen
moves, the eye will follow this movement. Consequently, it
10 will no more integrate the same cell over a frame (static
integration) but it will integrate information coming from
different cells located on the movement trajectory and it
will mix all these light pulses together which leads to a
faulty signal information.

15 Today, a basic idea to reduce this false contour effect is
to detect the movements in the picture (displacement of the
eye focus area) and to apply different type of correction
over this displacement in order to be sure the eye will only
perceive the correct information through its movement.

20 Nevertheless, in the past, the motion estimator evolution
was mainly focused on other applications than Plasma tech-
nology and the aim of a false contour compensation needs
some adaptation above all in the use of the motion vectors
coming from the motion estimator.

25 As already said, a dynamic false contour reduction will be
applied on a movement trajectory defined by the motion vec-
tors. Nevertheless, since the panel is a matrix array of
pixels, we need to convert a motion vector to a way in this
matrix with the respect of the human visual system behavior.

30 For that reason, we propose in this document a way to im-
prove the quality of the false contour reduction using stan-
dard motion detectors with a post-processing of the esti-
mated motion-vectors according to the human visual system.
It could be implemented for each kind of Plasma technology
35 at each level of its development (even if the scanning mode
and sub-field distribution is not well defined).

4

Considering above artefacts, occurring on the retina, different inventions based on a motion estimator exist in the literature today. All these inventions will used the motion vectors coming from the motion estimator to apply different

5   kind of compensation. Nevertheless, there is no information about the way to use these motion vectors or about a possibility to improve them.

In fact, since a PDP is a matrix of pixel, each kind of correction has to respect this matrix segmentation of the

10   panel. Taking into account a motion vector, it will be used to determin in the matrix of pixel a trajectory to apply the compensation. For that purpose it is necessary to convert a vector in a discrete trajectory which can leads to faulty or partial compensation.

15   In this invention, the characteristics of the human visual system will be used to implement a post processing on the vectors coming from the motion estimator. That makes possible to define a compensation trajectory respecting the human eye in order to improve the global quality of the compensa-

20   tion.

This algorithm improves the efficiency of each dynamic false contour correction based on a motion estimator since it better respects the behavior of the human visual system,

This algorithm is very simple to implement since it does not

25   request complicated computations

As previously said, a Plasma Display Panel (PDP) utilizes a matrix array of discharge cell which can only be "ON" or "OFF". The PDP controls the gray level by modulating the

30   number of light pulses per frame. This time modulation will be integrated by the eye over a period corresponding to the human eye time -response.

Let us assume, we want to dispose of 8 bit luminance levels, in that case each level will be represented by a combination

35   of the 8 following bits :

1 - 2- 4 - 8 - 16 - 32 - 64 - 128

To realize such a coding with the PDP technology, the frame period will be divided in 8 lighting periods (called sub-fields), each one corresponding to a bit. The number of

5   light pulses for the bit "2" is the double as for the bit "1"... With these 8 sub-periods, it is possible through combination, to build the 256 gray levels. Without motion, the eye of the observers will integrate over about a frame period these sub-periods and catch the impression of the right

10   gray level. The next figure presents this decomposition :
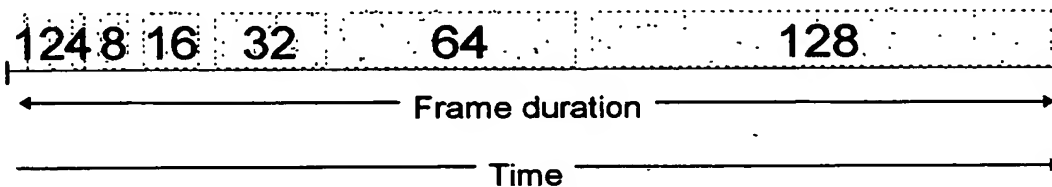
This light emission pattern introduces new categories of im-

15   age-quality degradation corresponding to disturbances of gray levels and colors. These will be defined as dynamic false contour since the fact that it corresponds to the apparition of colored edges in the picture when an observation point on the PDP screen moves. Such failures on a picture

20   leads to an impression of strong contours appearing on homogeneous area like skin. The degradation is enhanced when the image has a smooth gradation and also when the light-emission period exceeds several milliseconds.

In addition, the same problems occur on static images when

25   observers are moving their heads and that leads to the conclusion that such a failure depends on the human visual perception.

To understand a basic mechanism of visual perception of moving images, a simple case will be considered. Let us assume

30   a transition between the level 128 and 127 moving at 5 pixel per frame, the eye following this movement.

The next figure represents in dark green the lighting subfields corresponding to the level 128 and in green, these corresponding to the level 127.
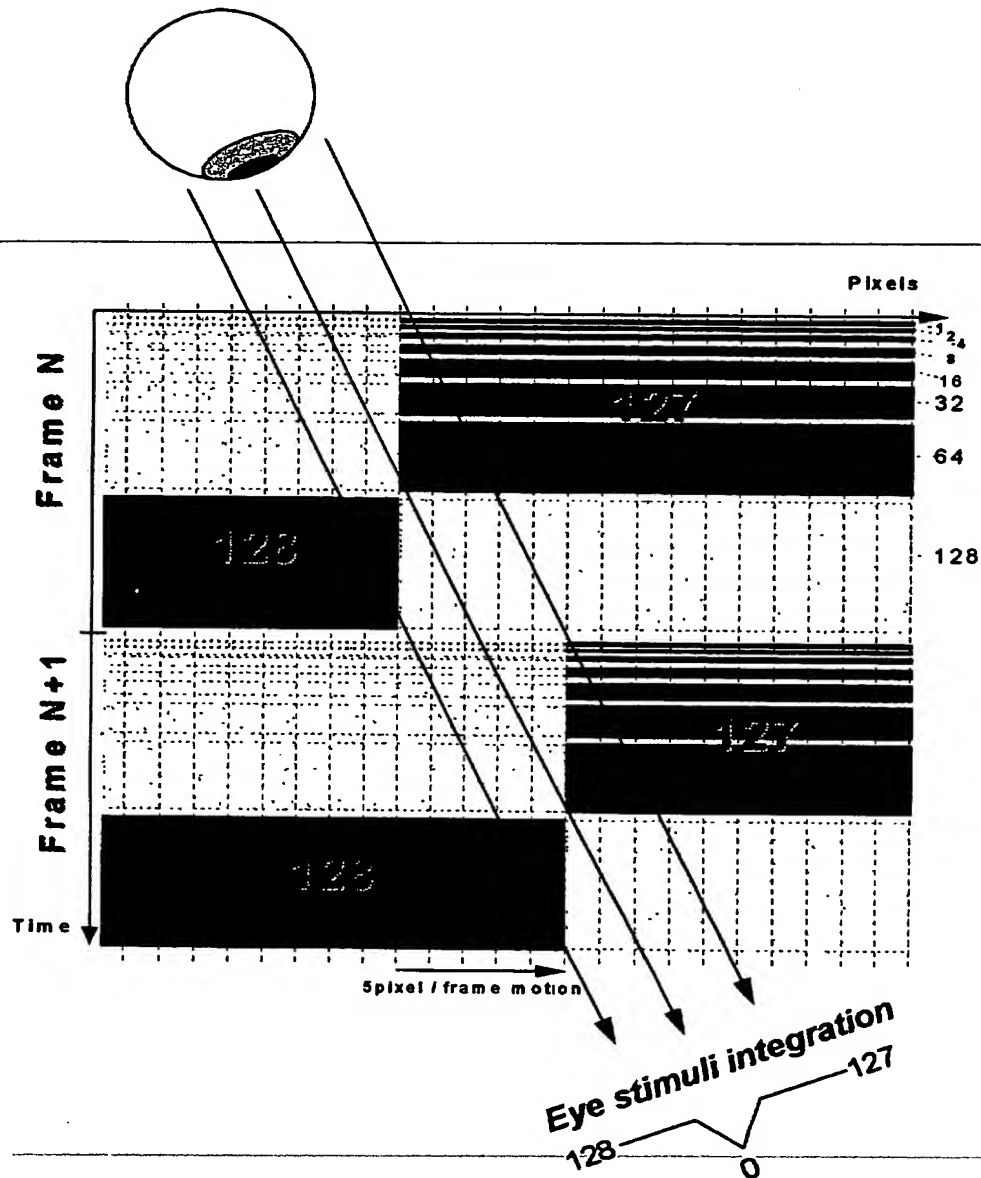
On this last figure, we can follow the behavior of the eye
5   integration during a movement. The two extreme diagonal eye-
integration-lines show the limits of the faulty perceived
signal. Between them, the eye will perceive a lack of lumi-
nance which leads to the appearing of a dark edge like on
the next figure :

10

Amplitude
on the eye cells
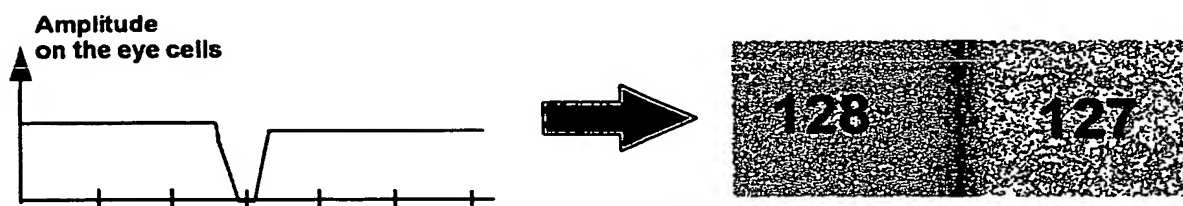
2. Principle of dynamic false contour compensation

The false contour effect is produced on the eye retina when
5 the eye follows a moving object since it integrates right
information at wrong places. There are different methods to
reduce such an effect but the more serious ones are based on
a motion estimator (dynamic methods) which aim to detect the
movement of each pixel in a frame in order to anticipate the
10 eye movement or to reduce the failure appearing on the ret-
ina through different correction.

In other words, the goal of each dynamic algorithm is to de-
fine for each pixel locked by the eye, the way the eye is
following the movement during a frame in order to generate a
15 correction on this trajectory.

Consequently, for each pixel of the frame N, we will dispose

of a motion vector $\vec{V} = (V_x ; V_y)$ which describes the complete

motion of the pixel from the frame N to the frame N+1. Nev-
ertheless, the goal of a false contour compensation is to
20 apply a compensation on the complete trajectory. In other
words, such an algorithm needs a way to convert this vector
in a trajectory on a matrix display.

Taking the example of a vector $\vec{V} = (7;3)$, the next figure
shows that the definition of this vector is not enough to
25 determine one trajectory :
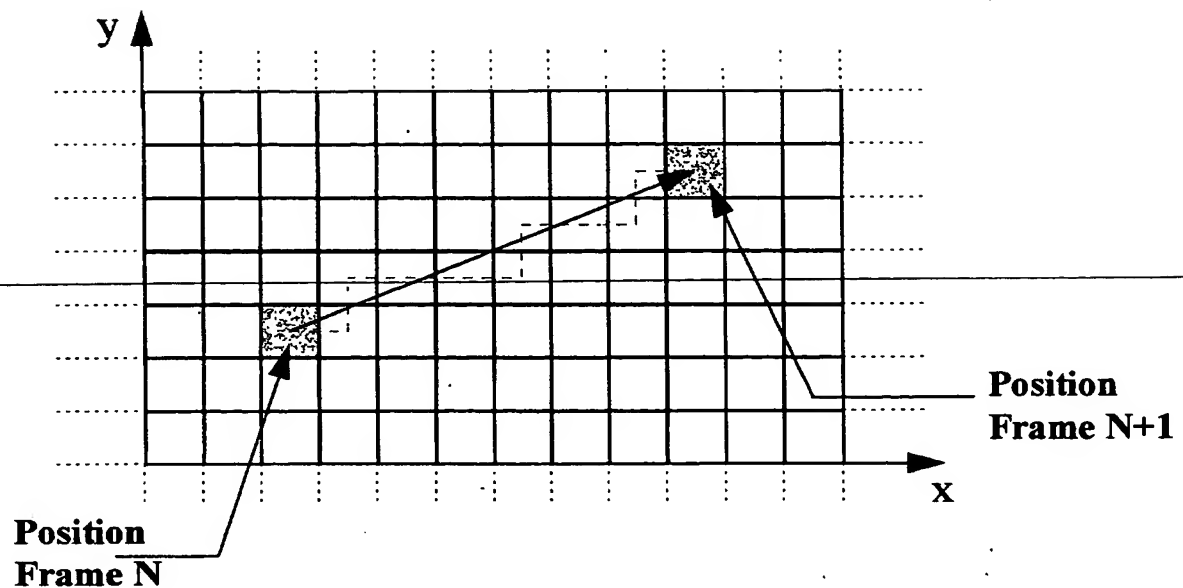
On the previous figure, the vector represents the real mo-
tion of a pixel, that means the real trajectory the eye will
follow when it locks this pixel. The doted line represents a
possible trajectory in the matrix array. Yet, there are dif-
5   ferent other possible trajectories and it is necessary to
define a trajectory as near as possible from the eye inte-
gration trajectory. In order to do that, a better under-
standing of the human visual system is recommendated.

10

3. Human visual system (HVS): cortex areas
The complete human visual system could be seen as a picture
encoder to reduce the informations received by the retina to
essential informations which could be rapidly interpreted by
15 the brain.
For instance, the pupil could be seen as a low-pass filter
which reduces the amount of high spacial frequencies. The
goal of this document is not to make a complete exposition
of the human visual system but to extract some important
20 characteristics from the HVS to explain the ideas included
in this invention disclosure.
One key point for us is the fact that the cortex areas will
analyse the incoming picture with a discrete filter bank as
described in the following picture :
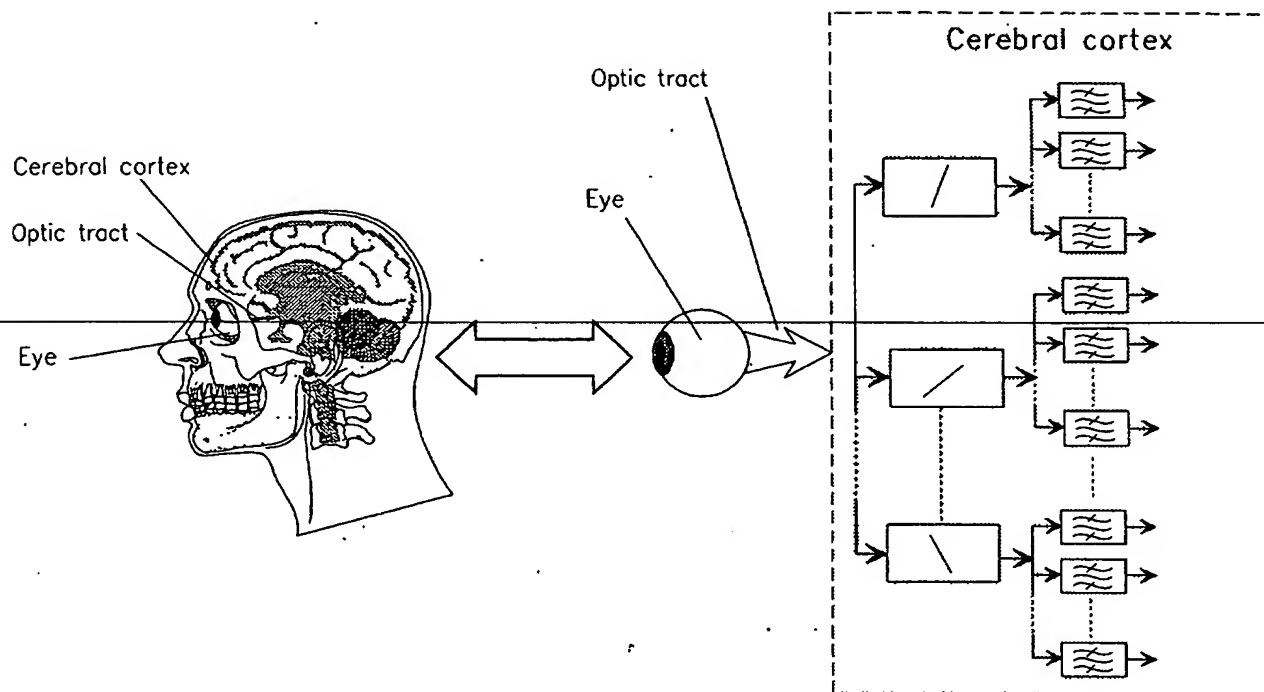
This last figure shows that the signal coming from the eye will be analyzed between preferential directions and the

5 number of these direction is limited (discrete analysis). In order to measure the exitation intensity in each direction, each directional filter will be followed through a filter bank in spacial frequencies.

In fact, medical experiments have shown that this decomposi-

10 tion through a filter bank can be seen as a mathematical de-composition in gabor wavelets which are very near from the simple receptor fields of the cortex cells.

The mathematic formula of such a gabor wavelet is the fol-lowing one :

15 $$f_o = \exp\left(-\pi\left[(x-x_o)^2 a^2 + (y-y_o)^2 b^2\right]\right) \times \exp\left(-2i\pi\left[u_o(x-x_o) + v_o(y-y_o)\right]\right)$$ where

(x_o, y_o) represents the position of the filter modulated by

the spacial frequencies (u_o, v_o) and with an orientation of

$$\arctan\left(\frac{v_o}{u_o}\right).$$

The two following curves represents the aspect of such a ga-

20 bor function. The first one representing a 3D aspect of the
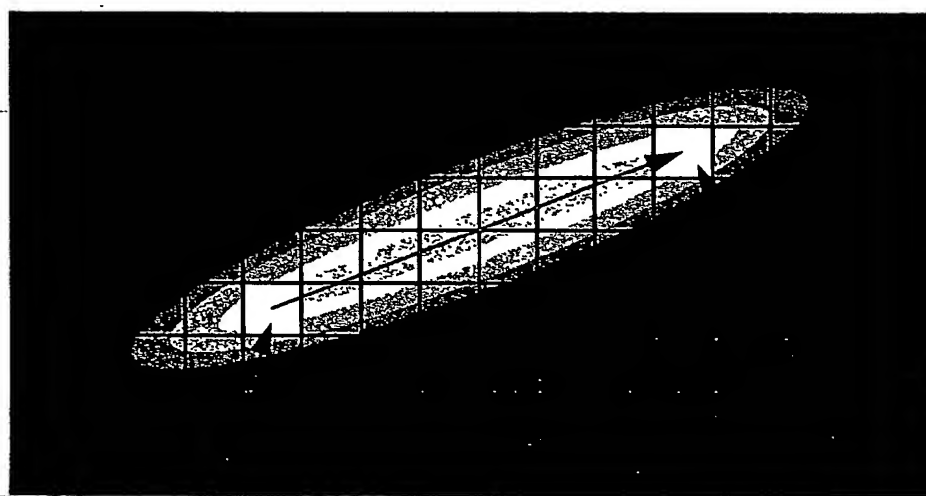
10

gabor function, the second one representing a colored 2D as-
pect of the same function.
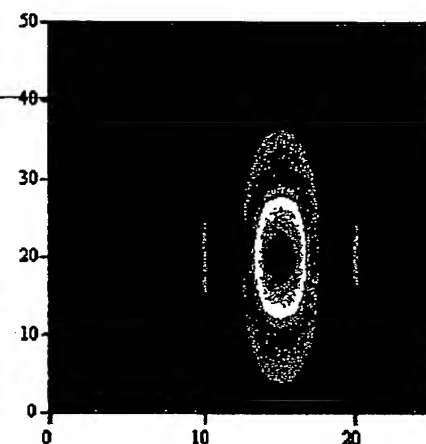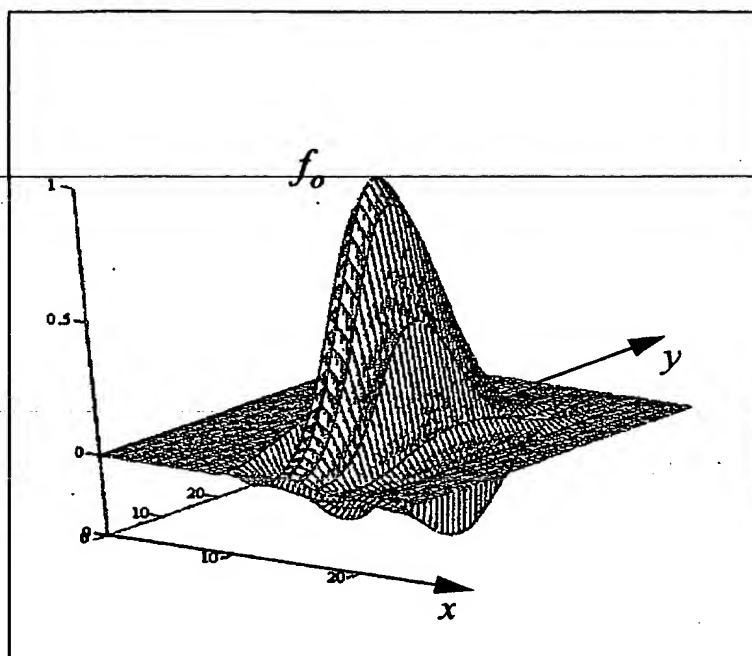
5

These graphics shows how the eye will analyse an object
transition or a movement in a special direction.
Let us apply the 2D curve on the previous moving pixel with
the vector $\vec{V} = (7;3)$

Position
Frame N+1

Position
Frame N

10

11

On this previous picture, the middle area (directly arround
the vector) represents the more sensitive one for the eye
integration. Consequently, each kind of dynamic false con-
tour compensation should be spread on this area which really
5   define the compensation trajectory.

The basic idea of the algorithm described in this document
is to define a vector post-processing method which enables
such an adaptated compensation.
10

4. Algorithm principle
In theory, the different motion vectors could have any kind
of values and so any kind of direction.
4.1. The first stage is to convert the two vector components
15   to an integer:
The aim of each compensation is to reduce, in the right di-
rection taking into account the right amplitude of the move-
ment, the false contour effect.
In fact, since the compensation has to be applied on a ma-
20   trix array of pixels (discrete positions), the two motion
vector components have to be integer ones to apply a correc-
tion on a discrete trajectory (defined with integers). In
that case, it is necessary to round the vector components
coming from the motion estimator. Every kind of rounding can
25   be foreseen. Nevertheless, experiments made on different
available motion estimator shows that a rounding down could
improve the final result. In order to simplify the further
explanations a rounding down will be chosen for the rest of
this document .
30   It is obvious that a compensation which is based on a lower
value of the movement amplitude but which respects the right
direction will still provide a gain in the reduction of the
false contour. On the other hand, if the compensated motion
amplitude is too high, we will generate a false contour ef-
35   fect in the opposite level to the effect we will try to com-
pensate. In addition, the fact to jump from an under-

12

compensation to an over-compensation will suddenly change
the color of the false contour and that makes it more visi-
ble.

Consequently, for all computations one kind of rounding has
5   to be precisely defined and an under-compensation (used mo-
tion amplitude lower than the real one) will be chosen for
~~further explanations.~~

For that reason, the first stage of the algorithm will con-
vert each vector component to an integer with a rounding
10   down to the neariest lower integer:

$$\vec{V}_1 = \vec{V}\left(round \downarrow (V_x), round \downarrow (V_y)\right).$$

4.2. Conversion of standard vectors to basic ones :

Before to go further, an example of a improperly correction
15   will be given to introduce the new computation methodology.

Taking into account a
simple correction based
on 10 pixels in the
case of a trajectory
defined with the vector
$\vec{V} = (7;3)$ the following
correction could be
faulty implemented :
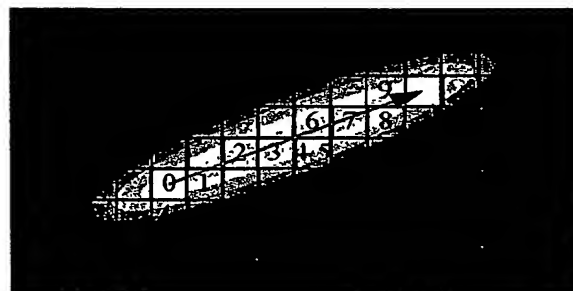
**Position
Frame N+1**

**Position
Frame N**

On this last figure, the number corresponds to one of the
20   ten elements of the compensation. It is obvious that this
compensation does not respect the symmetry of the human eye
integration function and leads to a non-optimal false con-
tour correction.

In fact, we have seen in the paragraph 3. that the human
25   cerebral cortex will decompose each movement and stimuli in
preferential directions. In fact, since the human visual
system does not dispose of an infinite number of such direc-
tions, those directions could be defined as discrete ones.

13

For that purpose one principle of the algorithm is to con-
vert our vectors to a discrete number of direction (convert
all vectors to simplest ones which leads to a more symmetri-
cal compensation).

5   We have seen in the paragraph 4.1. that our vectors are
based on integers and consequently, the direction given by
each vectors is based on the ratio between the two integer
vector components.

In order to build a discrete space of directions, a good
10   possibility is to define each vector as based on two compo-
nents having an integer ratio inbetween.

For that purpose, the second stage of the processing de-
scribed here will correspond to a modification of the vector
components as described below :

15   select the smallest vector component: $S = \min(V_x, V_y)$

compute the ratio R between S and the second component:

$R = \dfrac{V_t}{S}$ in which $V_t = \max(V_x, V_y)$

round the ratio R and then update the second vector compo-
nent: $V_t' = round(R) \times S$

20   For instance the vector $\vec{V}(7;3)$ will be converted to the vec-
tor $\vec{V}'(6;3)$ and the vector $\vec{V}(2;9)$ will be converted to $\vec{V}'(2;8)$.
These two vectors are a part of a discrete space of vectors
and their form leads to a better symmetry of the compensa-
tion.

25   Now, this processing will be illustrated through an example
based on a Sub-field shifting algorithm. This algorithm is
explained in detail in the European Patent applications
98114883.6 and 99114587.1 of the applicant. For the disclo-
sure regarding this algorithm it is therefore expressively
30   referred to these patent applications.

Taking into account as example a motion vector defined by
$\vec{V} = (7.3; 3.7)$ and the case of a 12 Sub-field coding described on
the next picture :

14

| 1 2 4 8 16 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |

Frame period
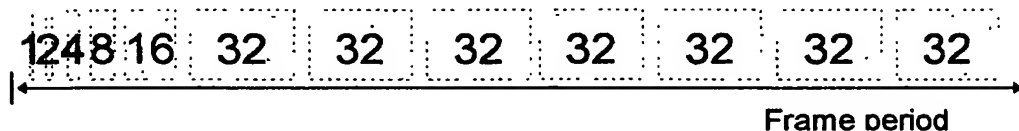
Conversion of standard vector components to integers one

$$\vec{V}' = (7;3)$$

Conversion of the new vector to a basic one

5    $\vec{V}'' = (6;3)$

Computation of the correction positions

The main idea of the sub-field shifting algorithm is to anticipate the movement in order to position the different bit planes of the moving area on the eye integration trajectory.

10   That means we will shift the different bit-planes depending on the eye movement to make sure the eye receive the right information at the right time. For that purpose we have defined centers of gravity :
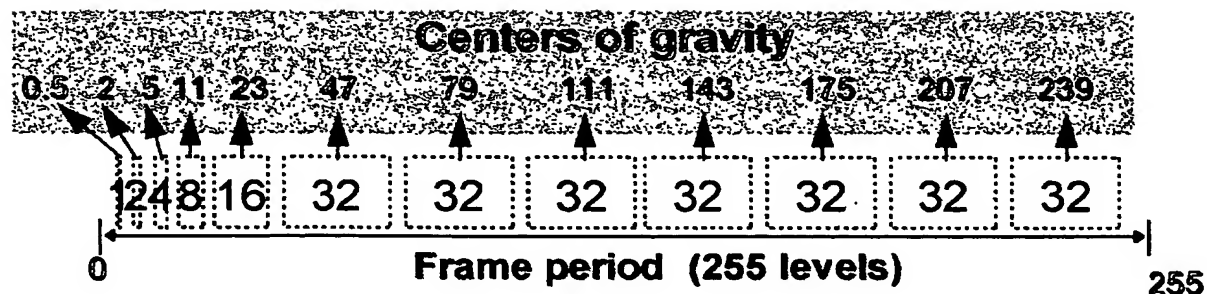
$$G(n) = \sum_{i=1}^{i=n-1} Dur(i) + \frac{Dur(n)}{2}$$

in which G() represents the center of gravity location in

15   the frame, n the current sub-field and Dur() the duration of the sub-field. This duration includes the addressing time as following :

$$Dur(n) = Tadd + Tn$$

in which Tadd represents the duration of the addressing and

20   Tn the duration of the sub-field itself.

For instance, a result of such a computation should be :

Centers of gravity

0.5 2 5 11 23   47   79   111   143   175   207   239

| 1 2 4 8 16 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |

0   **Frame period (255 levels)**   **255**

Giving a motion vector $\vec{V} = (Vx;Vy)$, the new position of the

25   sub-fields will be so calculated : $\Delta x_n = \dfrac{Vx \cdot G(n)}{Dur(F)}$ and

15

$$\Delta y_n = \frac{Vy \cdot G(n)}{Dur(F)}$$ in which, Dur(F) represents the complete dura-

tion of the frame.

In our example where $\vec{V} = (6;3)$, we will find the following re-
sults :

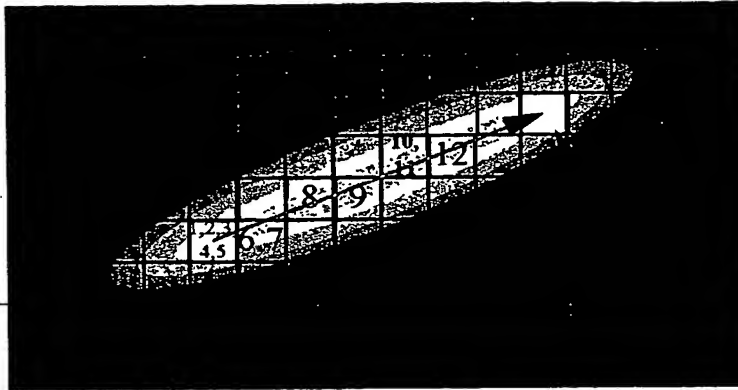| Sub-field N° i	1	2	3	4	5	6	7	8	9	10	11	12
$\Delta x'$	0.01	0.05	0.1	0.26	0.54	1.1	1.85	2.6	3.36	4.1	4.87	5.6
$\Delta y'$	0.005	0.02	0.06	0.13	0.27	0.55	0.93	1.3	1.68	2.05	2.43	2.8

5

Compute how the correction will be applied

Since a correction could only be applied at one single posi-
tion defined by two coordinates in the matrix of pixel, we
will have to round the previous computed values. Different

10 kind of rounding process could be applied and for this exam-
ple a round down process of each previous computed coordi-
nates has been chosen to respect the choice of paragraph 4.1
to make under-compensation (obviously over kind of compensa-
tions are possible) :

Sub-field N° i	1	2	3	4	5	6	7	8	9	10	11	12
$\Delta x'$	0	0	0	0	0	1	1	2	3	4	4	5
$\Delta y'$	0	0	0	0	0	0	0	1	1	2	2	2

15

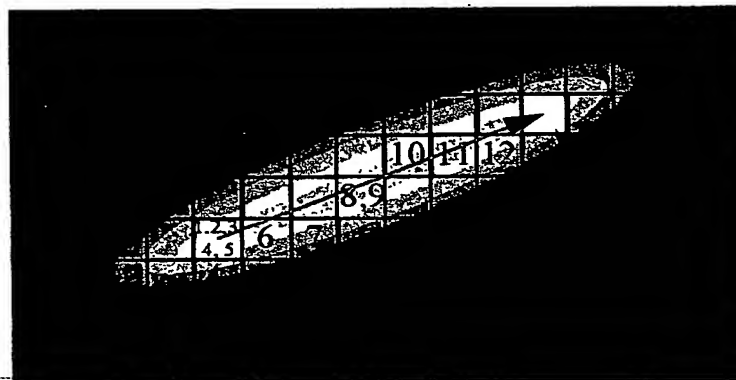On the following picture, we can see the result of this com-
pensation:

Position
Frame N+1

Position
Frame N

compared to a standard compensation based on $\vec{V}' = (7;3)$ in which we have implemented only a rounding down process :

Sub-field N° i	1	2	3	4	5	6	7	8	9	10	11	12
Δ_x'	0.01	0.05	0.14	0.3	0.63	1.29	2.17	3.05	3.92	4.8	5.68	6.56
Δ_y'	0.006	0.02	0.06	0.13	0.27	0.55	0.93	1.3	1.68	2.05	2.43	2.8

Position
Frame N+1

Position
Frame N

5   A comparison of these two last figures shows that the second one does not respect the symmetry of the human visual system. In that case, the experience shows some artefact produced by the compensation itself even in areas where no
10   false contour is visible. In addition, when the vector space is discrete, the compensation stays more stable between two serious vector changes.

4.3. Case of correction made on amplitude basis :

Today a lot of correction based on motion vectors will be
applied on amplitude basis. In that case, one possibility is
to add a positive or negative signal to the original pic-
5   tures at different positions depending on the motion vectors
(A lot of other kind of corrections could be find in the
literature...).

In that case, at each matrix position a combination of two
or more corrections can be applied. Consequently, giving a
10   correction, one or two positions for this correction can be
defined in the matrix.

Using the assumption of appliing a correction based on N

elements to the trajectory defined by the vector $\vec{V} = (V_x ; V_y)$.

For instance, a simple way to compute the position $P_i = (\Delta'_x ; \Delta'_y)$

15   is defined by the formula : $\Delta'_x = i \times \dfrac{V_x}{N}$ and $\Delta'_y = i \times \dfrac{V_y}{N}$.

Nevertheless, in order to respect the symmetry of the gabor
function, a special rounding processing will be applied.
This aims to produce an artificial symmetry in the compensa-
tion. In that case, each compensation could be applied at
20   one or two positions like described below :
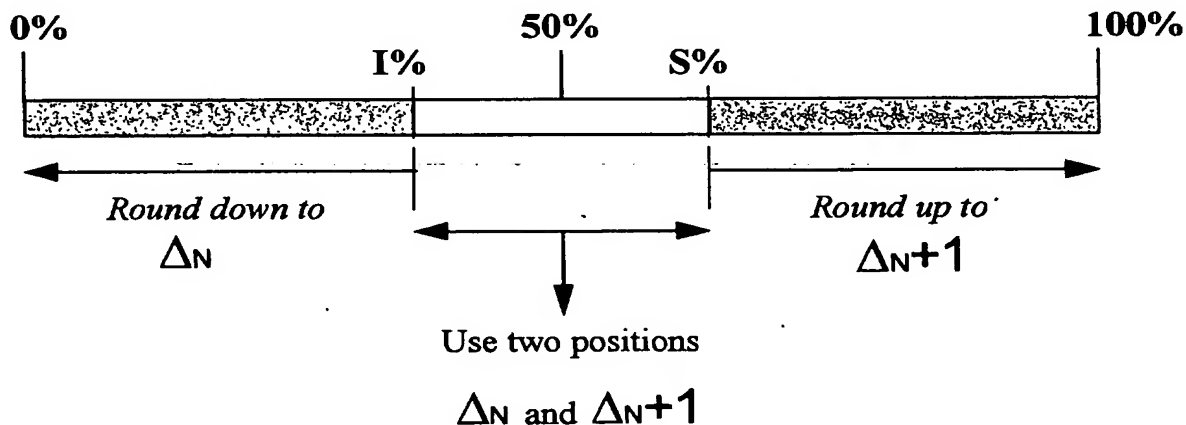
This last figures describe the following processing :

If $\Delta'_\varepsilon = i \times \dfrac{V_\varepsilon}{N} \leq I\% \times round \uparrow \left(i \times \dfrac{V_\varepsilon}{N} \right)$ then $\Delta'_\varepsilon = round \downarrow \left(i \times \dfrac{V_\varepsilon}{N} \right)$

If $I\% \times round \uparrow \left(i \times \dfrac{V_\varepsilon}{N} \right) < \Delta'_\varepsilon = i \times \dfrac{V_\varepsilon}{N} \leq S\% \times round \uparrow \left(i \times \dfrac{V_\varepsilon}{N} \right)$ then

$$\Delta'_\varepsilon = \begin{vmatrix} round \downarrow \left(i \times \dfrac{V_\varepsilon}{N} \right) \\ round \uparrow \left(i \times \dfrac{V_\varepsilon}{N} \right) \end{vmatrix}$$

If $\Delta'_\varepsilon = i \times \dfrac{V_\varepsilon}{N} > S\% \times round \uparrow \left(i \times \dfrac{V_\varepsilon}{N} \right)$ then $\Delta'_\varepsilon = round \uparrow \left(i \times \dfrac{V_\varepsilon}{N} \right)$

Obviously, the border I% and S% could have different values

5 depending on the compensation algorithm used.

Let us illustrate this processing through a simple example
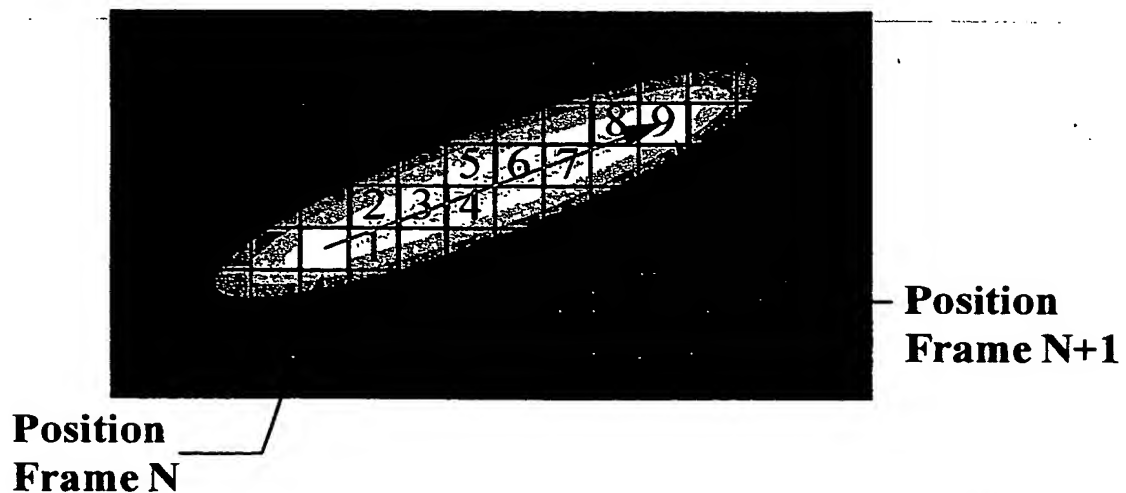
in which the vector $\vec{V} = (6;3)$ and N=9.

Case of I%=40% and S%=60% :

10 The following table show the computation of the positions

for the 9 corrections defined by $P_i = \left(\Delta'_x ; \Delta'_y \right)$

Correction N° i	1	2	3	4	5	6	7	8	9
Δ'_x	1	1	2	3	3	4	5	5	6
Δ'_y	0	1	1	1	2	2	2	3	3

In that case, the implementation of the correction will look

like as on following figure :

15

Position
Frame N+1

Position
Frame N

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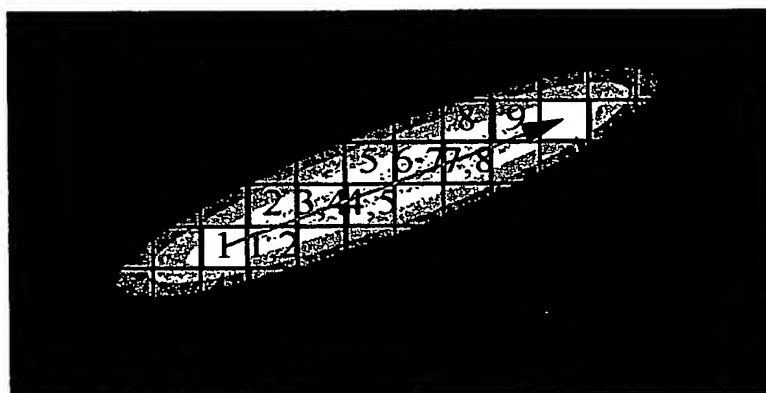The numbers located in the different pixel blocks refer to the correction signals.

Case of I%=30% and S%=70% :

5

The following table show the new computation of the positions for the 9 corrections defined by $P_i = (\Delta'_x ; \Delta'_y)$

Correction N° i	1	2	3	4	5	6	7	8	9
Δ'_x	0, 1	1	2	2, 3	3	4	4, 5	5	6
Δ'_y	0	0, 1	1	1	1, 2	2	2	2, 3	3

10   The following figure shows how the compensation will look like :

Position Frame N+1

Position Frame N

Consequently, a change of the values from I and S will have an impact of the density of the correction on the movement
15   trajectory.
In fact, in the cells containing more than one correction, a combination of these corrections will be necessary and will depend of the correction type.

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Claims

1. Method for processing video pictures for display on a display device having a plurality of luminous elements corresponding to the pixels of a picture, wherein the time duration of a video frame or video field is divided into a plurality of sub-fields during which the luminous elements can be activated for light emission in small pulses corresponding to a sub-field code word which is used for brightness control, wherein motion vectors are calculated for pixels, **characterized in that**, the motion vector components are rounded to integer values, wherein in the rounding step the components are rounded down irrespective of their rational component value and wherein the motion vectors are used to determine corrected sub-field code words for dynamic false contour effect compensation.

2. Method according to claim 1, wherein the rounded motion vectors are converted to a more symmetrical form before they are used for sub-field code word correction.

3. Method according to claims 2, wherein the following steps are used for motion vector conversion:

first, the smallest motion vector component S is selected where $S=\min(V_x, V_y)$ with V_x and V_y being the motion vector components;

second, the ratio R between S and the other motion vector component V_i is calculated, where $R=V_i/S$ and $V_i=\max(V_x, V_y)$, with $i \in [x, y]$;

third, the ratio R is rounded and the other motion vector component V_i is updated according to the formula $V'_i = round(R) \cdot S$.

4. Method according to one of claims 1 to 3, wherein sub-field shifts are calculated for pixels in dependence of the corresponding motion vectors and wherein a rounding step is performed for each sub-field shift component during sub-field shift calculation, wherein in the rounding step the sub-field shift components are rounded down irrespective of their rational component value.

5. Method according to one of claims 1 to 3, wherein a correction value is calculated for a pixel on pixel level for dynamic false contour effect compensation and wherein the correction value is distributed among a number of pixels which are determined by the calculated motion vector.

6. Method according to claim 5, wherein the pixels $P_i = \left(\Delta_x^i ; \Delta_y^i \right)$ which are used for correction value distribution are defined by the formulae $\Delta_x^i = i \times \dfrac{V_x}{N}$ and $\Delta_y^i = i \times \dfrac{V_y}{N}$, where N is a number according to the number of pixels over which the correction value is to be distributed corresponding to the length of the motion vector $\vec{V} = \left(V_x ; V_y \right)$, where i is an index running from 1 to N, wherein a specific rounding process is used for correction pixel location, wherein if the rational component value of a vector component Δ_x^i, Δ_y^i lies in a first range, the vector component is rounded down, wherein if the rational component value of a vector component lies in a second range, the vector component is rounded up and down thus leading to two different correction positions in parallel, and wherein if the rational component value of a vector component Δ_x^i, Δ_y^i lies in a third range, the vector component is rounded up.